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GENERAL SCIENCE.—*The scientist in the Federal Service.*[1] ALFRED H. BROOKS, Geological Survey.

A presidential address places the auditors completely at the mercy of the speaker, for custom rules that no matter how pitiless his barrage of heresies they may not return his fire. On the other hand, while it is obeying the order "Attention!" the audience is able to examine the enemy's position in critical detail, to note the accuracy of his fire, and to determine the destructive effect of his projectiles. Still a retiring president has the advantage in that he can venture a frontal attack with safety and, if he does not reach his objective or even hold ground temporarily gained, can retire to his trenches of oblivion before a counter attack can be launched.

In this stronghold of Government science it is the part of boldness to discuss the scientists in the Federal service, about which most of you have first-hand information and all of you, no doubt, have fixed convictions. As some measure of defense I shall not omit the time-honored plea of lack of opportunity for exhaustive study, though it may come very ungraciously from one who has been so greatly honored.

The conceptions of the Federal investigator are so varied as to make the task of giving a composite picture of him absolutely hopeless. To the man on the street the Federal scientist is a learned gentleman who, supported by Government bounty, leads in general an easy and indolent life but who on occasion, by some legerdemain, saves a situation. In the industries he is classed by some as a saving angel, by others as a freak, who, because he asks foolish questions and shows a tendency to pry into affairs of others, may be a public pest, one who at long intervals avenges any slight by inflicting a report on the public, written in words that cannot be understood. A few academicians appear to view the Federal scientific corps as composed chiefly of persons of mediocrity who are occupied in routine, propaganda, lobbying, and self-aggrandizement.

[1] Presidential address delivered before the Washington Academy of Sciences, January 10, 1922.

One who would know the Federal scientist must trace him to his lair and must learn his habits while he is running wild on his native heath. His environment is peculiar and must be studied to understand his reaction to it. Are his physical and mental variations from the type of *Homo scientificus* sufficient to justify the setting up of a new species? The biologic phase of the problem is beyond my ken, but I venture the opinion that the Federal scientist does not differ from the average investigator. During a century of evolution this great army of scientists fortunately has not developed a sufficient class consciousness to make it a unit. The strongest critics of Federal science come from within the service, not from without.

The unique intellectual and social atmosphere of Washington, the history and the magnitude of Governmental scientific institutions, and the definite limitations set by law have developed an environment for the Federal scientist quite different from that of the investigator supported by private funds. His field is multifarious in character and continental in dimensions; it includes every branch of science and every industry, and it ministers to the material and educational needs of over a hundred million people. His available resources in funds, however, limit his activities to only part of his field, and his apparently boundless opportunities are closely circumscribed by very definite laws which prescribe both his methods and, to a large extent his objectives.

Detailed knowledge of the conditions of Federal research must needs be based on a close scrutiny of every one of the forty-odd bureaus devoted in whole or in part to scientific inquiry. This scrutiny I have not essayed, for it is beyond the capacity of anyone even had he infinity of time. Moreover, I have a suspicion that such a self-imposed critical inquiry would not be conducive to the long and happy life in Washington that I hope to enjoy. It is fortunate, therefore, that the examination of the affairs of individual bureaus is not essential to learn the general conditions that control Federal research.

The peculiar atmosphere of Washington, a city of Government and little more, has exercised an important influence on Federal science. Here science has been advanced by prescription of law and not by force of tradition or local demand. During a century there has been developed here one of the great scientific centers of the world, and it is a center that is not greatly affected by outside influences. Only during the last two decades have researches other than Governmental found seat at the National capital. Washington's institutions of

higher learning were founded chiefly to meet the needs of her citizens, and their influence on Government science has been negligible. Other scientific centers, such as Paris, Berlin, and London, have grown up under a different environment. In these cities science was fostered by old universities and learned societies long before national research was begun. In consequence, Government science in Europe has been closely coordinated with the great institutions of learning and has been molded by their traditions and personnel. The learned societies of European countries have also had a strong influence on Governmental science. In contrast to this, Federal science in the United States has been developed without academic traditions or without close affiliation with university investigators and it has been little influenced by learned societies. The National Academy of Science, founded half a century after the beginning of Federal research, though charged by law with advisory duties to the Government, has only occasionally been called into consultation. Indeed, before the war the Academy as a body was often out of direct touch and apparently somewhat out of sympathy with scientific work in Washington. Now that it has undertaken the difficult task of coordinating research throughout the land, it has come closer to the Federal investigator. The influence of the National Academy in the past, however, has been very different from that of l'Institut de France and the Royal Society of Great Britain.

Federal science has developed its own traditions, set its own standards, and followed its own self-chosen paths. It may not be denied that this freedom from academic tradition has made for an independence of thought that is not without value. On the other hand, it is not well that the contact between Federal and university science is less close than it was a generation ago. The Federal bureaus are sometimes too prone to regard the universities only as training schools. On the other hand, many of the universities, not clearly understanding the purpose of the Federal service, are overcritical of its results in part, no doubt, because these do not always meet the special needs of the teacher.

Another dominating feature of Washington science is its exclusively professional character. Most Federal investigators devote their entire time to science and find their social life among their professional colleagues. It is science morning, noon, and night, with but few other intellectual interests. In contrast to this, the university scientist divides his time between teaching and research, and the vast majority

of his colleagues are engaged in other intellectual pursuits. Thus the scientific investigator in a university, living in an atmosphere of wide intellectual interests, is usually more scholarly than the investigator in the Federal service. On the other hand, the university scientist has no rivals among his immediate associates, and his results do not always run the gauntlet of stern criticism, as do those of the Federal scientist. The university scientific groups therefore have a tendency to become mutual admiration societies. This tendency and the worship of his disciples among the students sometimes lead the university scientist to become a professional oracle whose dicta may not be denied. Such a mental attitude prevents right thinking, and it is fortunate that the Washington atmosphere is unfavorable to its growth.

If Washington were larger and had more diversified interests, like European capitals, it would include a large number of amateur scientists. I use the term amateur in lieu of a better word to designate the nonprofessional investigator, who is not to be confounded with the dilettante. The amateur brings into science an enthusiasm for his subject which in the professional sometimes becomes dormant. It is unfortunate that he is almost unknown in Washington, for he could do much to vivify science, which may become too much a matter of the day's work to the Federal investigator. Local scientific societies, too, would be benefited by the enthusiasm of the amateur, for these societies are highly specialized, and their meetings too often resemble a council called by some bureau chief. The few amateurs in Washington, though welcomed at these meetings, are not likely to find the atmosphere of professionalism congenial to their aspirations. The university investigator, on the other hand, has the advantage of contact with the amateur as represented by his students.

Most European scientific centers are in large industrial cities, but the industries of Washington are solely those needed to support the population domiciled at the seat of Government. Federal investigators must therefore seek contact with the business world at places away from the scene of their principal activities. Though may of them do so, the scientific service as a whole is isolated from commercial life. Industry sometimes makes the charge that the products of Washington science, because of this isolation, are impractical, meaning thereby that they cannot be used at any given time for commercial profit. Obviously, if a scientific principle is true it cannot be impractical, and it falls to the technician to determine whether it can or cannot be applied to the advantage of industry. This mis-

understanding of the purpose of science is due to lack of clear distinction between the fields of the investigator and of the technician. The investigator establishes a principle of science; the technician utilizes that principle to improve some practice of industry. The confusion of thought is increased because in some fields the investigator may also be the technician and may himself apply to industry the results he obtains from research. Many scientists in the Federal service are acting in this dual capacity. Many inventors and nearly all scientists employed by industry are doing the same thing. However successful and valuable such scientists may be, the fact that the Federal service is largely free from the direct influence of the business world has without question been of great advantage to science and therefore to industry.

Those who are not in touch with Washington life and who know the city chiefly as a political center may hold that the political environment must have an important influence on Federal science. Such an opinion is without basis of fact. Political Washington and scientific Washington are almost as far apart as the poles. One is in constant flux; the other is relatively permanent. One has its strongest ties elsewhere; the other is rooted deep locally. One is typically assertive; the other is deliberative. Political and scientific Washington have, indeed, only one common ground—that of public service. Chiefs of scientific bureaus come into contact with political leaders in setting forth the results, purposes, and needs of their organizations, but the Federal scientific investigator himself is seldom called from his laboratory, and then only because of his special knowledge of some problem of public welfare or policy. These and other occasional contacts with political life are of advantage to the scientist in broadening his outlook on the needs of the people and they should give him a sounder opinion in choosing a field of research than that held by his professional colleague in private life.

The founding of the Coast Survey in 1816 marked the beginning of the Federal scientific service, though some small grants for investigations, chiefly explorations, were made in earlier years. For more than half a century the growth of the service was very slow. Fifty years ago, when the Philosophical Society of Washington was founded, it had only 38 members, and during the succeeding decade, though it remained, except for the Medical Society,[2] the only local scientific

[2] Founded in 1819, with 21 members. The Anthropological Society was organized in 1879, with 28 members.

organization, its membership increased to only about 200. It is probable that during its early years the Philosophical Society included in its membership all the scientists in Washington, and that most of these were in the Government service.

In the time available I have been unable to learn accurately the number of scientists now in the Federal service. There are some forty-odd Government institutions devoted in whole or in part to scientific work, and their employees number many thousands. That only a small number of these should be classed as scientists goes without saying, but the attempt at classification would not only necessitate a close scrutiny of the duties of many individuals, but even then the result reached would be a matter of personal opinion. By actual count in the directories of the Washington Academy of Science, I venture the opinion that the local societies included 600 Federal scientists in 1910 and 770 in 1920. On the other hand, I am informed by Dr. Robert M. Yerkes that in 1919 there was a total of 4,888 scientific and technical employees in the Federal service. It is probably safe to estimate that there are in all a thousand scientific investigators in the Federal service at Washington. Some of the scientific bureaus have much the larger part of their personnel stationed away from Washington. It is therefore estimated that the Federal employees who are making at least some contribution to science number about fifteen hundred.

Though these figures are only approximations, they give a measure of the enormous growth of the scientific service during the last fifty years. This increase has indeed taken place chiefly during the present generation. Before tracing the circumstances leading to the present huge Federal scientific service, I wish to picture Washington as a scientific center at a time antedating its enormous expansion.

The typical scientific bureau of a generation ago consisted of a group of independent investigators studying problems chiefly of their own choice and by their own methods. Organizations then centered on the individual scientist, in contrast to the present practice, by which the problem or the special field determines the administrative unit. Devotion to science was the ideal, often to the exclusion of any thought of public welfare, now accepted as the important duty of Federal investigators. Indeed, there were some who boasted that the results of their research could have no useful purpose. Applied science was then so rudimentary that an investigator was perhaps justified in holding that by advancing knowledge he was fully meeting his obliga-

tion to the public. Nevertheless, nearly all the bureaus, in theory at least, were established to meet some material need, though in practice this need was often lost sight of. Some executives appear to have been willing to authorize researches without too careful a scrutiny of the limitations imposed by law. The chief of a scientific bureau looked upon the allocation of the annual grants of funds and a personal appeal to Congress for increased appropriations as his principal administrative duties and regarded them as disagreeable though necessary interruptions to his own absorbing researches. Appropriations were more often granted because of the personality of the bureau chief than because of a recognized need of scientific inquiry.

By tradition the scientific bureaus were regarded as things apart from the Federal administrative machinery and were subjected to little interference. Though some heads of departments took pride in directing research, most of them paid small heed to scientific bureaus, deeming their work of only academic interest. In those days the scientist, being seldom called into consultation on public affairs, was largely left to his own devices. There was little pressure for his results, for neither industry nor the public at large were vitally concerned with them. A scientist's work room of that day was more like a private study than, as now, a business office. Its tranquillity was seldom disturbed by the rattle of the typewriter or the jingle of the telephone bell. Stenographers were few, and many treatises were laboriously written with pen, to the evident advantage of their diction. Nor was the investigator greatly disturbed by routine matters, the tremendous growth of which has been concomitant both with the development of large organizations and with the increase in the demands of the public for enlightenment on problems of applied science. Fiscal regulations were as abundant then as now, but the marked laxity of their enforcement in many scientific bureaus enabled the investigator to evade those he regarded as irksome. The small personnel in bureaus and even in departments called for few regulations and restrictions. There being no civil-service law, each investigator, in theory at least, was left untrammeled in his choice of assistants. This condition made political appointments possible, and these were by no means unknown in the service.

Many of the investigators were called to the Federal service because of their long recognized standing at the universities, and in general there was a closer affiliation between the scientific service and the institutions of learning than there is now. A considerable per-

centage of the appropriations for research were allotted to university men and the grants being held to be subsidies for research, there was little supervision of their use. This practice followed that of most European countries, which maintained only skeleton governmental scientific institutes and supported research chiefly by allotments to individuals. It may be noted in passing that the exigencies of the war led in part to abandonment of this policy in Europe and resulted in a much greater centralization of research.

A generation ago few universities were able to train specialists, and the young assistants usually had only a general scientific education, though they had a better academic background than those of the present. All expected to serve a long apprenticeship before they launched out as independent investigators.

In early days of Federal science there was not only scant supervision of the investigators but little scrutiny of the results they submitted for publication. The group leader was regarded as competent to determine the validity of his conclusions, and the less experienced assistant was not intrusted with independent investigations. Differences of opinion between scientists were left for them to settle between themselves. Washington science not being held to be of practical value, the public was indifferent whether this or that theory received official sanction. Indeed, there was no such thing as an official dictum, and the originator of a thesis was left to his own devices in defending it in the public arena.

Some exceptions to the above statements should be noted. For example, the Coast Survey, while holding to its long established scientific ideals, was engaged in the very practical work of serving the mariner by charting the shore lines. Again, the work of the Weather Service could not be done with the loose administrative methods that were common to most of the other bureaus. Its stricter organization was no doubt due to its military control.

Living costs in Washington were very low, and the small salaries sufficed to meet the requirements of the simple standards of that day. A family with an income of $2,000 was then better off than one today with $6,000. The corps of investigators was so small that, though officially more independent than now, its members were professionally and socially closer together. A large part of it assembled in the small rooms of the Cosmos Club on Monday nights, where much of the coordination of science took place under the inspiration of a mug of beer and the smoke of a churchwarden pipe. The more formal

discussions were reserved for the Philosophical Society, long the meeting place of the investigators in all sciences who were not too highly specialized to maintain a lively interest in the work of their colleagues.

The atmosphere of Federal science during this early period may be likened to that of a university, at present it resembles that of an industrial establishment. The investigator had little cause to make concessions to the public, either in choice of field or length of time devoted to a problem. To him came conditions favorable to constructive thinking and scholarly presentation. If there were some who yielded to a certain soporific influence in their tranquil environment, their lack of results was offset by the work of those who found in this environment the opportunity for independent effort and great accomplishment.

The great changes wrought in the Federal scientific service during the last generation were accomplished by gradual evolution, but this was greatly accelerated during the present century. Long before, however, the practical applications of science had greatly multiplied. Federal bureaus had been much enlarged, and their scope had been changed. Along with these changes had come closer control of the investigator, together with a clearer recognition of both the spirit and the letter of the law. The change from the individualistic to collective method was indeed fully under way.

The improvement of business methods was most marked after 1906, when the recommendations of the Keep Commission were introduced as far as possible without legislative action. These recommendations fairly revolutionized departmental business methods and were the first decisive step toward eliminating Governmental red tape. The Keep Commission, unlike most others having a similar purpose, was made up entirely of men long experienced in the Federal service and was therefore in a better position to introduce reforms than those who were unfamiliar with the work of the departments.

Collective action by scientific service first crystallized when, because of the needs of the conservation policy, the Federal investigators undertook, by order of President Roosevelt, an immediate census of national resources. Then, for the first time, nearly all branches of Federal science acted with a common purpose and were asked for very definite, practical, and above all quantitative data. This taking account of stock by the trustees of the Nation revealed both the strength and the weakness of Federal research as well as its great

utility to the Nation. One result was the promulgation of stricter rules and more definite instructions and the placing of greater limitations on the freedom of the individual. By far the more important result was the realization by the higher Government officials of the value of science in solving problems of national economics. This realization has ever since been one of the most potent influences in directing Federal research toward problems connected with the public welfare.

Certain conditions that are peculiar to the Federal scientific service have been noted; others will now be mentioned. Those noted have played an important part in the evolution of Governmental research during its century of growth from a single bureau with a few investigators to two score institutions manned by more than a thousand scientists. Far more important to this evolution and indeed an integral part of it is the advance of science itself and a change both in the type of the investigator and in the broadening of his ideals. These changes are worldwide; they are not peculiar to the Federal service. It will be well, therefore, to trace some of the factors involved in the genesis of modern methods and ideals of research.

Three facts stand out clearly: First, science has become a profession—it is no longer an avocation of men engaged mainly in some other calling; second, science has become organized and is not now advanced solely by uncoordinated individual effort; third, science by becoming more exact has become more useful. The transition from the old to the new era has not been synchronous in all sciences. Medicine was a profession long before the modern epoch of science. The work of the astronomer and geodesist was professional, organized, and useful long before that of the naturalist. It will be a matter of opinion as to whether the three facts above set forth are chiefly the cause or the effect of the progress of science. Until the investigator could give his full time to research, progress could be made only by halting steps. On the other hand, until industry found science useful not many professional positions could be open to the investigator. Again, the multiplication of scientific researches to meet the demands of industry called for better organization, and this again has led to the advance of science.

The professional scientist—that is, the scientist who gives his entire time to investigation, is a comparatively new figure. A generation or two ago he hardly existed; anyone who undertook research then had to support himself by teaching or by some occupation re-

mote from science. Even as late as the beginning of this century opportunities to the scientist for professional employment were by no means alluring. In contrast to this, not only are there now thousands who, under public or private auspices, find a means of livelihood in scientific work, but the demand for scientists exceeds the supply. Every branch of investigation offers a career to the earnest student. Scores of examinations are held for positions in the Federal scientific service, and many others are offered by the States and the industries. The student of the present day on choosing his career can weigh carefully the financial as well as the professional opportunities offered. His predecessor had no financial motives, for the best he could expect was only a bare living. In 1846, when Spencer Baird found his salary had reached the dazzling sum of $400 a year, he felt that he could well afford to get married.

In the old days a few great teachers passed their knowledge along to small groups of enthusiastic disciples. Now the universities are annually graduating scores of highly trained specialists, who are by education far better fitted to advance science than those of a generation ago and who after a short apprenticeship can be trusted with independent research. They supply the highly trained and brilliant investigators that are so typical of the present era. On the other hand, some of the products of the graduate schools bear the stamp of being machine made. It sometimes happens that the new investigator is the result of opportunities offered by a university, rather than of an inspiration for a scientific career. A man's exhaustive knowledge of the facts relating to some specialty is no measure of his ability as a constructive thinker. A student may believe he has a call to science when actually what appeals to him is simply the fact that science is an honored profession and a career giving promise of employment. At the time when the profession of the scientist was hardly existent, the investigator was a product of natural selection and must have had that God-given love of his subject for which no training can be substituted. Science was then not a profession but an obsession.

Berzelius is credited with the statement that he would probably be the last man who could know all chemistry, meaning thereby that the science had grown so large that it was becoming beyond the grasp of a single mind. Since his day the naturalist has been supplanted by the botanist, zoologist, and geologist. These have given way to the taxonomist, pathologist, ecologist, glaciologist, and paleontologist, to name only a few of the present subdivisions of the older

professions. The end is not in sight, for as science becomes more exact a still higher degree of specialization is certain. Now a scientist may not even know the meaning of a word that describes the work of a professional colleague.

The tendency of modern scientific education is to produce specialists and not scholars. Advance of science must be effected by specialization, yet the question may be asked whether the investigator who cannot see the forest for the trees is not too great a factor in research. Unfortunately, the specialist is sometimes little more than the collector of dull facts he cannot or will not interpret. In relation to their facts some specialists may be likened to the Indian chief who, because of a certain peculiarity, was called "Man-afraid-of-his-horses." Sweeping generalizations in science are a thing of the past or of the ignorant; yet in spite of the overwhelming number of facts now available, there is perhaps room for a little more boldness in their use.

There is danger at the present rate of accumulation that the scientist may never overtake the continual inpouring of facts. Whenever a research promises to bear the fruit of theory, a possible source of new information may be revealed, and thus interpretation may again be deferred. Nowhere is this more evident than in the Federal service, now perhaps the largest storehouse of scientific facts in the world, including many that are only shopworn. There is a tendency in the service to neglect interpretation. Many Federal investigators could well cease for a time to be collectors of new facts and devote themselves exclusively to an understanding of facts already on file.

When any branch of science has been developed to the point that adequate knowledge of it can no longer be held by an individual but must be distributed through a group of investigators, how are its larger problems to be solved? The answer evidently lies in cooperative effort, without which that branch of science cannot continue to progress. This brings me to the important question of the organization of research.

Through countless centuries science was advanced by the devoted investigator working alone, and it was during this individualistic period that it took root in our own country. As science progressed there was an increase in cooperation, which first took the form of grouping of investigators at universities and museums and the founding of scientific societies and periodicals. Gradually more orderly methods of inquiry and later definite units of research were developed. The evolution of research proceeded from individualistic to cooperative

and finally to organized methods. The organization of research, though long under way and hastened by the war, by no means covers the whole field of science and indeed never can, for much of scientific progress must always be individualistic.

Some of the physical scientists were the first to undertake collective action. The astronomers and geodesists early recognized the necessity of national and international cooperation, and later the meteorologists realized that their work could not be greatly advanced by the individual. Still later men engaged in other physical sciences that require long periods of continuing observation found the value of organization. The natural sciences long lagged behind the exact sciences in this movement, and even today much of their investigation is essentially individualistic. Organization has now gone so far, however, that we have come to think of scientific progress in terms of institutions rather than of individuals.

One grave fault of organized science is that it leaves no place for the amateur, who in the past has done so much useful work. The amateur cannot now hope to compete in the fields occupied by large institutions, with highly organized corps of professional investigators, and in consequence, he is active only in some of the least organized natural sciences. This is unfortunate, for many an amateur is as able an investigator as the highly trained professional and may have an even greater love of science. Science, indeed, originated with the amateur, and until recently he was the chief instrument in its progress. Now, however, he is being crowded out, and soon he may be as extinct as the dodo.

The administration of scientific inquiry in large units originated in the Federal service but has been greatly expanded under private auspices. Whatever faults we may find in these colossal public and private institutions, their all-important work in advancing science cannot be denied. The mere fact of their great multiplication and growth during the last two decades proves that they are meeting a public need. This striking departure from the old methods of research finds no parallel in the history of science, and the origin of its form of administration must be sought in the business world. The government of these institutions, like that of a corporation, includes a board of directors, represented by Congress or by trustees, that approves the general plan of operations but leaves details to an executive who may or may not have a cabinet of advisors. Though the methods of conducting such institutions vary in detail, their basal principle is

essentially autocratic, and their success can be taken as evidence that a wise and benevolent autocracy is a better instrument to advance knowledge than a democracy. Indeed, this form of administering research finds a close parallel in the government of our universities. It appears, therefore, that the centralization of authority in learned institutions, be they educational or investigative, is following a natural law of evolution and has not been arbitrarily superimposed on science, as some believe. Moreover, it is but one manifestation of the very general national tendency toward autocratic administration of both public and private affairs.

As institutional research is the very keynote of modern science and dominates Federal inquiry, it will be well to scrutinize its methods and to consider its merits and demerits. Research institutions differ greatly in their scope and objectives, but the advance of some branch of science is the common aim of all. Their chief differences lie in the field of investigation chosen, and this is determined principally by the terms of their financial support. A few institutions are entirely untrammeled in the selection of problems, but the great majority must give preference to this or that phase of science. The work of the Federal bureaus is very definitely controlled by law, and most of them are compelled to give first heed to industrial problems. There are also private endowments, like those made for medical research, whose principal purpose is to investigate problems of public welfare. Much of the investigation of industrial problems is conducted under private auspices. This work includes that done by institutions whose purpose is to advance the common interests of certain industries, but much the larger part of it is done to gain information that will be of direct profit to those who are furnishing the financial support. In an attempt to classify research institutions, two groups can be recognized. One group will include all institutions whose investigators are made directly for the public benefit; the other will include those whose investigations are made for private profit. Some measure of the public appreciation of science could be had if the ratio were known between the expenditures made for these two classes of investigations. I venture the opinion that the annual disbursements for commercial research far exceed those for public research.

Nearly all research is supported by trust funds, and this fact had led both public and private institutions to establish very definite regulations controlling expenditures. There are, indeed, some who appear to hold that the scientific ideals of an investigator are lowered if he

is called upon to follow good administrative methods. Yet, it is evident that unless expenditures for research are made on sound business principles the confidence of the public will be lost and financial support will fail.

It may not be denied that the recent progress in science has been very largely the work of the modern research institutions. The mere massing of investigators is in itself a benefit, for it produces a certain amount of attrition that tends to remove those bumps of self-esteem which are not unknown among scientists. Moreover, a large institution gives a serious and professional atmosphere to the investigator that is not without great advantages, though, as already pointed out, it has some drawbacks. The more direct benefits to science of organized investigation are self-evident. Many problems can be solved only by the cooperative effort of investigators in several specialized fields. The successful solution of others depends on long-continued and widespread observations that are beyond the power of any individual. Moreover, researches that involve large expenditures should obviously not be dependent on any one person. Another advantage of institutional over scattered investigation is economy of administration.

It is not difficult to recognize weakness in the basal principle of organized research. Its trend is toward uniformity and the subordination of the individual in the interest of the whole. In theory at least each investigator of an institution is but a cog in the great machine of collective effort, yet it is by no means certain that collective is superior to individual mental effort in the production of constructive thought, without which research amounts only to the collection of facts. Therefore, organized research, if it is to advance science, must ever avoid the pitfall of drab uniformity in both effort and result if it is to escape mediocrity. This danger may be avoided by the brilliant executive, who can judge to a nicety just how far individuality may be encouraged without endangering results that are to be attained only by coordination.

Good administration will seek to develop the individual scientist, whatever may be his capacity. In the enunciation of plans for research it is sometimes tacitly assumed that all investigators are of the same general type as the best. Yet most scientific work will always be done by men of average capacity, and good collective results can be achieved only by assigning to each man the task he is best fitted to perform. Humiliating as it may be to our professional pride,

most scientists are and must remain hewers of wood and drawers of water, and a proper organization of research will take due account of this fact.

In former days each investigator advanced science by interpreting facts he had himself ascertained. In contrast to this, there are now many problems whose solution depends on the collection of so large a number of precise facts that the task is far beyond the capacity of the individual observer. This condition has developed the observational type of scientist, a man who is both highly trained and makes an enormous contribution to knowledge and whose very lack of marked mental independence makes him all the more valuable as an observer and recorder. The observational investigator obtains his best opportunities in a closely administered institution. This is also true of the investigators of minor problems of science, whose best results will be achieved under close supervision. On the other hand, the scientist of marked individuality may not obtain the best results under the conditions of organized research. The rare scientific genius, however, needs no special environment to reach his highest development, for he cannot be suppressed.

With this classification of investigators it will be evident that the vast majority will do better work as members of an organization than as individuals, and this alone is a very strong argument for institutional research. Such a conclusion, however, postulates good administration of science, some of the difficulties of which may be considered.

A director of research should have the qualities of the impresario, for the scientist, like the artist, is temperamental and refuses to be cast in the common mold. Though originality of thought must be cultivated in every scientific institution, there is a constant danger of its overproduction. A scientist may apply his originality not only to research but also to financial and routine matters, at a serious loss of efficiency. It is indeed astounding how many unnecessary difficulties a brilliant investigator can create by ignoring simple business methods.

Many scientists have for years groaned under the Federal system of accounting, without ever understanding its basal principle. Government disbursement is, indeed, complex and growing needlessly more so, but difficulties come chiefly to executives and professional accountants; the average investigator meets only its simplest forms. The days are past when the efficiency of a Federal bureau was gaged by the perfection of its vouchers, and although disbursements must

comply with the law, they are not now held to be an end but only a means to an end.

Many a scientist, however, still believes that he has been singled out as of proved dishonesty because some official has directed his attention to an infraction of the law. He does not see either that close regulation of Federal disbursements aggregating billions of dollars is necessary or that the legal safeguards must apply to small as well as to large transactions. Indeed, many scientists are ignorant of the principle of all fiscal regulations, namely, that the law holds all Government moneys to be trust funds. The law also provides that every trustee must be able at all times to submit documentary proof that he has not stolen the funds in his custodianship. Therefore, upon every Federal employee who handles public funds or involves the Government in liabilities rests the burden of proof that his trusteeship has been honestly administered. Evidently all purchases are governed by the same principle, and the purpose of competitive bids is to prevent dishonest connivance between the seller and the Government agent.

Certain scientists regard the limitations placed on their fiscal operations as a personal insult and an attempt by a bureau chief to assert his authority. To them fiscal regulations have no purpose except to hamper research, and they never come to understand that a regulation is nothing but an interpretation of the law. If these men would master the basal principle of Federal accounting and the simple methods they are called upon to use they could command more time for their own work.

The fiscal regulations are particularly irksome to those who remember the time when they were but loosely enforced in the scientific bureaus. In those good old days scientists and sometimes even bureau chiefs gloried in successful attempts to evade the law, or in what may be termed "putting one over." Such practices resulted only in more stringent laws and interpretations. It is quite likely that Federal auditors have blacklisted individuals and even certain bureaus that have been found attempting to evade the law, and that their vouchers receive a specially searching scrutiny.

Yet there is certainly room for improvement in the laws governing Federal disbursements, as for example, in the restriction placed on the use of automobiles. It seems beyond human knowledge to understand why the use of horse-drawn vehicles is unlimited, while that of automobiles is closely restricted. It is as if Federal trans-

portation should be effected only by stage coach and canal boat instead of by railroad. But the origin of this anachronism is clearly traceable to some abuse in the employment of official automobiles for private use. This is an example of an ill-advised law enacted because of a breach of trust by some individual or small number of individuals.

It is also hard to understand why the Federal scientist should be penalized when traveling on official business by not being reimbursed for a part of his expenses. It would be equally logical to force him to contribute toward the cost of renting or heating his laboratory. The law limiting the amount paid for subsistence was passed because a former commission indirectly augmented the salaries of its professional corps by allowing a large per diem for subsistence, irrespective of whether the men were working at the home office or in the field. Unfortunately, Congress, when it uncovers such an exceptional abuse, is wont to believe that the abuse is general and enacts sweeping statutes, whose real purpose is to rectify the action of a few.

Although there is a growing tendency to increase the restrictions on Federal disbursements, yet we can comfort ourselves with the thought that both efficiency and economy are now included in the war cry. Probably the modification of less than a dozen statutes would suffice to do away with the obstacles that prevent Government work being carried on efficiently and therefore economically. It is a curious fact that most reformers have yet to discover that much of the proverbial Government red tape has been eliminated and that much of what is left is imposed by law and not by tradition or executive order.

A private institution of research supported by trust funds is also under the obligation to provide definite regulations to control expenditures. These regulations can, however, be framed to meet its special needs for it is not, like a Federal bureau, a very small part of a colossal organization charged with the disbursement of huge trust funds. The bureau chief must enforce the law as he finds it, even though he knows full well that it decreases the efficiency of his own organization.

I take it that all will agree that the first test of good administration of science will lie in the choice of investigators to do the work. In this matter the endowed institutions have a great advantage over those of the Government, in being able, in a measure at least, to adjust their salaries to meet competition in the commercial world. On the other hand, some will be attracted to the Federal service because

of the opportunities that it gives of being of direct human benefit. With these the call of science is no stronger than the call to aid their fellowman.

Positions in newly established institutions are in general eagerly sought, because of their promise to yield opportunities in untrodden fields. As a consequence the scientific personnel of such institutions will be of the highest type. These new organizations, moreover, are unhampered by the inclusion of investigators who have not fulfilled the promise of their earlier years. Unfortunately, the psychologist has not yet given us a formula by which the hundredth man can be definitely selected. Moreover, even though he may be found, a transfer to a new environment may produce an atrophy of his mind, for a scientist of a certain type seems to require the stimulus of obstacles to do his best work, and the easier his path the less productive his brain.

If no errors are made in the choice of investigators, the very independence of thought that characterizes the best investigators will in itself make difficulties for the executive head of an institution. He must foster individuality, yet he must mold the whole to produce collective results. The most valuable investigator may be the very one who most strongly resents any interference with his personal activities. Even Federal scientists, sometimes pictured as a set of brow-beaten investigators who dare not call their souls their own, are in truth most strongly independent. Their faults and difficulties have been clearly portrayed, but little has been said of their duties and responsibilities.

The scientist who joins the Federal service assumes other very definite obligations than those expressed in his oath of office emphasizing the defense of the constitution. Generations of scientists may pass who are never called upon to defend the constitution, but the responsibility to obey both the spirit and the letter of the law is always with them. Even more binding is the moral obligation to advance the interests of the people under whose bounty they are working. This implies, first and foremost, that they work for the truth and nothing but the truth, for without this ideal both pure science and applied science are but shams. These obligations have been fully lived up to by most Federal investigators. A few attempts have been made to gain popularity by premature announcements of assumed epoch-making discoveries, but these, like other short circuits, led to quick disaster. Some Federal investigators feel their responsibilities so

keenly as to err on the other extreme and become lax in the duty of giving any returns to the public.

The obligation imposed on the Federal scientist often runs counter to his personal ambitions. He chafes under a condition, imposed by law or by public need, forcing him to abandon some favorite field of research for one of less interest. It makes his unsought task no easier if, as sometimes happens, a colleague with only a rudimentary conception of public duty implies that he has abandoned pure science for some more popular field.

Every administrator of research finds his chief problem in the control of his scientific personnel. To some this problem appears most simple and involves only the giving of financial support to the master mind and then allowing it to wander whither it will. Such a course, however, will not lead to the solution of a cooperative problem. Moreover, the master mind, if left to its own devices, may wander entirely off the premises. The task of the executive is to harmonize the work of a group of strongly individualistic investigators, whose tendency is centrifugal rather than centripetal. Success will be achieved by a proper balance between individualistic and cooperative inquiry. There is the danger, on the one hand, of discouraging originality of thought, and on the other, of failing to maintain the necessary unity of purpose.

The executive in the Federal scientific service stands between the horns of a dilemma. If his bureau is not so organized as to provide very definite control of the work of the individual investigator he may fail to achieve the results demanded by the terms of his grants. If his organization is such that it does not give full play to constructive thought by the individual investigator he will accomplish little to advance his science. He must constantly strive to have his administrative machinery sufficiently elastic to develop the best mental work possible by each of his scientific staff. At the same time he must not ignore his obligation to give results to the public. Some investigators need constant spurring to obtain results; others need restraint, for their productions come so fast as to raise the suspicion that they may not be sound. Although the premature announcement of conclusions meets with quick punishment, the procrastinator often receives undue credit among his colleagues from the very fact that he has failed to make the evidence of his attainments public. Indeed, he often hampers the advance of science by occupying a field to the exclusion of others and by discouraging financial support for the organization

to which he belongs. If he is in the Federal service, his chief bears the moral responsibility for the expenditure of public funds on investigations that have come to naught. Not all investigators sense the moral responsibility for a return from researches supported by trust funds. The exceptions do not appear to realize that the final justification of any project is measured only the results achieved.

There will be differences of opinion as to whether scientific work in this or that field is yielding results commensurate with the outlay made for it, but the value of the great mass product of Federal science cannot be denied. In this day, when all Government expenditures are being closely scrutinized, the scientific bureaus can calmly welcome the fiercest light of publicity. I am sure that the unprejudiced examiner of public business will concede that the product of Government science is worth more than it cost and that no private corporation could obtain equal returns from the same expenditure. This fact in itself is proof of the high grade of the personnel in the scientific service. The thousand men engaged in this work include men of various types, and if it becomes necessary to record the faults of a few of them, these few are the exceptions—their faults do not characterize the group as a whole.

The delay in making public the results of research is one of the evils of the Federal service, but for this the scientist and the bureau are only in part responsible. Yet a considerable part of the blame rests upon the scientist himself, and his delinquencies may be due to his lack of certain mental, not to say moral qualities. The delinquents are of several types, and they include the investigator with a brilliant mind, which, however, is so undisciplined that it cannot be made to formulate conclusions. A very small percentage of the delays are chargeable to lack of a sense of moral obligation. This lack is shown by the dilettante type of investigator, who flits from one problem to another and seems to think that he fulfills all obligations if he simply remains on the Government payroll. Most often, however, the procrastinator is the hardest working of men, and his unwillingness to put forth conclusions is due to his fear of omitting some detail or failing to fully test some theory. We must respect such a seeker of truth, yet a part of his fault may lie in a certain conceit which induces him to believe that his results are so epoch-making that he trembles for the consequences to the Nation if they should be announced prematurely. It sometimes happens that before he has set the keystone of the arch that forms his *magnum opus* its founda-

tions have been undermined by some colleague, and the whole structure tumbles, becoming little more than a vast collection of misinterpreted facts. There is indeed always the danger that if the investigator withholds the results of an inquiry too long he will become "stale" on it before he has formulated his conclusions. Then the elaborate report may be only a jumble of facts whose interpretation must be left to others. It may even happen that the results of years of scientific research are entirely lost by the death of a dilatory scientist. It is a matter of record that every great scientist leaves a series of milestones that mark his progress, and when he attains the goal he need do little more than prepare a final summation of what has already been fully published to the world. Therefore, if no results from an elaborate research are announced the executive has a right to the suspicion that there will be none. To him then comes the important decision whether to continue expenditures on the project or to write it off in the profit and loss account. If he continues the work and nothing comes of it he has been unfaithful to his trust; if he stops the work there is always the danger that science and the people may be the loser.

Another problem in personnel is presented by the scientist who is as quick as a hair trigger in publication. He boldly rushes into publicity where the more experienced investigator fears to tread and, though he may be endowed with a certain superficial brilliancy, he is too impatient to carry his researches through to the end of establishing conclusions. His contributions may be likened to skyrockets—they illuminate the scientific landscape for a moment only to fall to earth and leave us in darkness. Such men are sometimes the pests of scientific literature, and some of them bury the results of their unfinished researches in huge, soon-forgotten tombs. If they gain admission to Government publications they may temporarily win undeserved reputations by the very size and elaborateness of their memoirs, though these may be the work of the pen rather than of the brain.

The secret of good administration in science, as in other affairs, is to make the best use of the personnel available. Experience shows that it is possible to guide the able investigator, but he cannot be forced to follow set paths. He has, moreover, the tactical advantage of not being "enlisted for the duration of the war," and he can probably obtain a letter livelihood in commercial work. Some of the most obstreperous members of the Federal scientific corps possess qualities that are most valuable to science and to the public service. If the

great majority of the Federal scientists were not always ready to do more than their full share in meeting their obligations to the public, the task of administering Government science would truly be hopeless. An executive who is taken into the public service from the business world and who has adopted the modern standards of efficiency would see no difficulties in administering research, for he would meet them by riding rough-shod over all scientists. Research, would be so organized that birds who can sing and won't sing would be made to sing. Every cog in the administrative machine would be compelled to do its proper work or make way for another. This plan does not make any allowance for the individual, nor for the fact that the brain cannot be forced to originate—that it cannot be thrown into gear by moving a lever. You cannot feed brains into a hopper and, by applying a sufficient number of mental impacts to your machine, produce a smooth-running new thought at the outlet.

Though organization and personnel are of fundamental importance to every research institution, yet the real efficiency of any such institution in advancing science will be determined largely by its choice of fields. The sternest critics of Federal bureaus have dwelt on errors in the selection of problems. Many of these critics hold that the preference for economic problems indicates both a lack of thoroughness in research and an abasement of scientific ideals. It is strange that no such criticisms have been made of the institutes of medical research, though their avowed purpose, like that of the Federal scientific bureaus, is to better the welfare of mankind. The high sources of some of these criticisms justify their consideration.

Every constructive criticism of the service should be welcomed, if only because it is well to see ourselves as others see us, but before its true value can be gaged it must receive proper correction for the personal equation of the critic. Most of those who enumerate the faults of scientific bureaus fail to distinguish between the faults due to law and those due to policy. Every Federal scientist recognizes the need for certain changes in law, but he is powerless to bring them about.

Meanwhile Federal scientists should not ignore the ominous signs that the skeleton in the closet of Federal research may at any time be exposed to public view—that the deceptive Government investigator may be unmasked. Already some critics have intimated that Federal science, though it may delude unthinking people, is not true research but something else not yet well defined. Classifications of research

institutions have also been made in which all Federal investigations are ignored. To the slur implied by this omission no reply is possible and the thousand or more Government scientists can but bow their heads in shame in the presence of those to whom the great light has come.

Though outwardly the Government investigators may remain calm in the face of the occasional storm of criticism that blows about their heads, yet often they find some note that harmonizes with their own feelings. Is there anyone in the rank and file of Federal scientists who has not at least one pet grievance and is not convinced that, if he were in charge of certain work, he could soon abolish some crying evil? Such grievances, though various, are most often, for lack of better definition, charged to bureaucracy. The wrong may have been committed by some cold-blooded auditor who, in enforcing the law, has blocked the progress of science by eliminating an item from an expense account. An investigator whose work is far in arrears may have found his chief very unsympathetic. It may be that the publication of some monumental treatise has been postponed for lack of funds. Again, official indorsement may have been denied for some pet hypothesis that, if only it prove true, will revolutionize science. It may be that a lack of funds forces an investigator out of his favorite field. The fault may be in a law by which the work of a bureau is made to include some activities that an investigator believes to lie outside of its proper scope.

The charge frequently made that the scientific service is employed chiefly on problems whose solution will directly contribute to the welfare of the Nation may not be denied. If this were not true the bureau chief would be a derelict in his duties to the public as well as a violator of law. The command that research be directed toward material ends is incorporated in the organic or appropriation acts of nearly every Federal scientific bureau.[3] For example, both the Coast Survey and the Naval Observatory owe their origin to the demands of the merchant marine and the Navy. The Geological Survey was established primarily to help to develop the country's mineral wealth and to evaluate the public domain. The needs of industry were met by the establishment of the Bureau of Standards

[3] The Bureau of American Ethnology appears to be an exception. The appropriation for the National Museum, made originally for the custodianship of Government property, can be said to have for its purpose the education of the people. The Smithsonian Institution is supported by a private endowment and is therefore an exception among Government institutions.

and the Bureau of Mines. Again, the demands of the farmers led to the setting up of scientific work in the Department of Agriculture. The value of a better knowledge of commercial geography, because of our expanding foreign trade, has recently been recognized in the policy of the Government.

There is a tendency to give the entire credit for the establishment of this or that scientific bureau to the genius and persistency of one man. Thus, Hassler is rightly associated with the founding of both the Coast Survey and the Naval Observatory, Ellsworth with the improvement of agriculture by Federal agencies, and King and Powell with the organization of Federal geologic surveys. Many other examples of the influence of certain men on the founding of the younger bureaus could be cited. Government science owes much to the broad concepts of these pioneers, but it must not be overlooked that they would have been powerless to accomplish their work if the conditions had not been favorable. Recognition by the Federal Government of the need of Government scientific investigation in any particular field is based on certain premises. First, the science must have made sufficient progress to give assurance that the results of the work to be done will in some way promote the general welfare. It must therefore have passed beyond the realm of speculation, and its results must be concrete rather than abstract. Second, the industry it is expected to benefit must be of enough national importance to create a wide demand for the results of the research.

In an absolute monarchy this or that investigation may be ordered for the mere sake of advancing knowledge, but in a representative government the argument for research must include very definite evidence that the people will be directly benefited by it. Once an investigation is established and concrete and practical results are obtained, plans for extending the research to more basal problems often receive support.

The sharp distinction attempted by some between investigations of purely academic problems, on the one hand, and investigations of problems of industrial and public welfare, on the other, needs consideration. I hold that this arbitrary division of scientific investigation has caused much confusion of thought. It is, indeed, unfortunate that no better designations have been found for these fields of inquiry than "pure" and "applied." If one is "pure" it would seem that the other must be "impure." If, again, research that is directed toward aiding industry is called "practical," as it has been, it would seem to

follow that all other science is impractical, a conclusion that will hardly satisfy its devotees. In making such a distinction it should be remembered that there is often a quick transfer of the results of pure science to the category of applied science. A scientific product so "pure" that it will stand the most searching "tubercular test" may be snatched for "applied science" before it has been fairly delivered at the doorstep of the consumer. If the exact meaning of the words is retained, applied science, or, indeed, we should say science applied to industry, must be restricted to the work of the technician and inventor who uses a scientific principle for some practical purpose. The principle may be the result of an inquiry either by an investigator whose only motive was to determine the law itself or by one who foresaw its possible practical use. The condition remains the same whether it is the application of the simpler laws of mechanics in the making of the formerly very useful device called a beer stopper or the application of the laws of physics in the building of a tide-predicting machine.

The difficulty of accurately defining pure science as distinct from applied science leads to the suspicion that there is really no basal difference between the two. No one can doubt the "purity" of inquiries into the laws of terrestrial magnetism, yet their practical value to the surveyor and the navigator cannot be questioned. A geologic map is clearly a contribution to pure science, yet who can foresee to what base use it may be put by the prospector? The results of any given research may be classified as to the validity of the conclusions, as to the value of the results to science, as to the ability of the investigator, and as to the thoroughness of the methods employed; but the scientist's motive for the research affords no logical basis for assigning it either to pure or to applied science.

Illogical as these terms may be, however, a lack of originality to invent new ones forces me to use them. In the commonly accepted phraseology, then, the term pure science includes nearly all university research and that of many endowed scientific institutions, and the term applied science includes researches that are avowedly devoted to industry supported by private funds, and also those of the great medical research institutions. The Federal scientific service is, however, the great stronghold of applied science, though it includes some researches, like those of the Smithsonian Institution, that must be classed as pure science.

Kelvin has said that "no great law in natural philosophy has been

discovered for its practical application." Yet he himself was one of the great users of science in practical affairs. Notwithstanding opinions to the contrary, there is almost overwhelming evidence that science has gained by its very marked drift toward material problems. It is certain that the vast sums now devoted to research are available because of the demands of industry. If investigations made for material ends do not advance science, we must grant that its progress is due to less than 10 per cent of present-day research.

It is sometimes intimated that the investigator working in economical fields has lower ideals than one who is employed in pure science. There is, indeed, no definite measure of man's ideal, but perhaps the best measure can be found in the unselfishness of his purpose. The scientist who is employed on a self-chosen problem and who is perhaps working in an ideal environment and with adequate financial support does not necessarily have higher ideals than one whose path lies in a less interesting field or one whose ultimate purpose is to improve the conditions of human life. The average investigator of the Federal service makes little parade of the motive of science for science's sake, yet his love of truth is no less than that of his colleague from the university of other endowed institution.

Another fallacy is the contention that pure science as contrasted with applied science leads to more thorough investigations. Yet the master mind will ultimately reach the basal principles of his problem, whether his researches are made in pure or in applied science. Any difference between the work of the investigations in these two fields is, indeed, solely a matter of mental equipment and bears no fixed relation to the line of approach. Many scientists have not the brain power to delve far below the surface and hence must remain cataloguers of facts who here and there reach a valuable general deduction. Some of this class, indeed, find a temporary abode in the realm of speculation, and the more academic their problem the longer they remain in that realm. If, however, their speculations relate to fields that touch human needs their sojourn in that high yet misty atmosphere is likely to be quickly terminated. Some materially minded man, mistaking their chaff for wheat, may make a practical application of some high-spun theory, with resulting disaster. No surer test of the validity of many a scientific hypothesis may be found than its practical application. Therefore, the scientist who is working with an eye to practical results is likely to weight his evidence more carefully than the one whose pronouncements are of purely academic

interest. In other words, if an investigator has the necessary brain power the fact that his researches are directed toward the solution of a practical problem will not prevent his reaching the very fundamentals. Moreover, the large majority of investigators are likely to be more accurate in their inquiries if the results are to be subjected to the acid test of industrial use.

Under the stimulus of industry every crumb of scientific knowledge is seized with avidity, and there is always danger of premature announcement of results. An investigator more anxious to obtain the plaudits of the public than to test the soundness of a theory may yield to this temptation. This has happened in the Federal service with the connivance of some bureau that hoped to receive support because of spectacular announcements rather than because of thorough work. The evil cures itself, for the punishment will be quick and drastic.

Some critics hold that the ideals of the investigator will be lower if his research is directed toward the solution of industrial problems. These critics are strangers to the inspiration that comes from hope of rendering service to the people. Most great inventors must have felt the same stimulus, even though they are generally credited with only the motive of gain. The sympathy of the people gives an inspiration to the investigator which is not exceeded by the expectation of advancing scientific knowledge alone.

"Science for science's sake" is sometimes used to express the highest ideal of the investigator. The essence of this borrowed phrase is simply love of truth, to which every scientist must always be loyal. Scientific ideals are not in danger because research may be directed to supplying the material needs of the Nation. The real danger lies in the investigator who, while parading his love of science, in reality makes this only secondary to his desire for self-aggrandizement.

It is a measure of our high scientific standards that some of the best opportunities for research come to those by whom they are well deserved, but the greater number of scientists must "carry on" under conditions as they find them, and perhaps even greater honor than that accorded to the favored ones is due to him who goes forward on a path strewn with difficulties. Science is not commercialized when it is used for practical ends; only when the investigator is working principally for his own profit. Yet we should not judge harshly those who have been driven by threatened bankruptcy to leave their laboratories and their professorial chairs for commercial life. This course is not

the fault of the individual; it is the result of the failure of the people to appreciate the true value of the work of the investigator.

The attempt is sometimes made to classify scientists not by their achievements but by their environment. The result is as artificial as to classify them by the number of capital letters they have the right to print after their names. Though scientific leaders have generally received recognition by well-earned honors, the tuft hunter is not unknown even among scientists. An honor conferred on such a one evidently proves nothing but success achieved in a very specialized field. This condition is unavoidable, and it in no sense detracts from the dignity of the honor rolls of learned institutions. It gives, however, an indication of the danger of any measure of merit except that of accomplishment.

The greatest scientists come from those whose love of truth impels them to make every necessary sacrifice to advance knowledge, and if by so doing they also better the condition of mankind they deserve all the more honor. Their devotion to science is too apparent to need shouting from the housetops, nor does its purity require the stamp of any registered brand. Such investigators evaluate the work of their colleagues by results and not by hair-splitting distinctions between pure and applied science. They know nothing about that rarified atmosphere that is so pure that it might be deadly to the Federal scientist if by accident he should be permitted to breathe it.

The Federal bureau chief who devotes the resources over which he has control to some urgent problem of public welfare is sometimes charged with truckling to popularity. This charge is occasionally just, but there are enough examples of the unpopular side of a controversy being taken solely from motives of public duty to prove that it is not a general rule. Indeed, many an executive has with deep regret turned from some important and attractive field of research solely because of a conscientious interpretation of the law.

The resources of the Federal bureaus, though considerable in the aggregate, are always inadequate to cover their fields of science. A choice must therefore be made among many problems, and this choice will be guided by the wants of the people. The selection of the field of inquiry by a Federal executive may be likened to that made by the explorer of a new land. In the interest of broad knowledge and by personal preference the explorer may first essay the precipitous and difficult slopes of its highest peak. He may hold that the wide view obtained from the summit will so greatly advance knowledge as

to fully justify the time and money necessary for the project. On the other hand, he may reflect that the attempt to scale the peak has no assurance of success until the foothills have been searched out and routes of approach discovered. Then, again, he may remember that his first object is to discover regions suitable for the abode of men. Because of these considerations he must decide to begin his exploration in areas of lesser relief and thus make his work of immediate benefit to the people. Just so the Federal investigator, in the performance of his public duty, must give preference to those fields of research that directly benefit the mass of the people he serves.

I have invited your attention to some of the adverse opinions on the policies of Federal research. Each of you will accept or reject them according to his own lights, yet they deserve earnest consideration by every American scientist. If those in the Federal service are not doing their share to advance science they are not living up to their trust. If those out of the service are convinced of this they too have a public duty to perform. Be this as it may, there is another and very serious aspect of the matter. The whole spirit of American science today is one of cooperation. To promote this spirit the time of many eminent men and considerable funds are being expended. If the large body of investigators in the Federal service are unjustly charged with lower ideals than those in private employment a serious schism will develop in American science that cannot be healed by the appointment of committees.

Though we may agree that the general policy of the scientific service is sound, yet we must admit that there are tendencies that should be checked. One of these is the drift toward technology. Many Federal institutions are charged by law with both scientific and technologic investigations, and the two fields cannot always be definitely separated. Yet there is danger that researches into the fundamental laws of science be neglected, though these laws must obviously be learned before they can be applied to industry. Nearly all Federal investigators are pressed for results, and consequently they have a natural tendency to give preference to the smaller problems —those that do not consume too much time. Some of the problems thus chosen might well be left to industry, and the funds devoted to searching out the more fundamental principles.

Perhaps the most crying evil in the service is the endeavor to accomplish too much. Our vast area and our complex industries lead to demands that cannot be met with the resources available. The

attempt to cover too wide a field is the result in part of general policy and in part of the ambitions of the investigator. The result of this attempt is that most of the conscientious workers in the Federal service are overburdened. It is clear that nearly every bureau is undermanned for the tasks it undertakes, especially now that so many of the investigators are newcomers. Much of the work is carried forward by the wheel-horse investigator, whose progress is slow and steady and whose load is constantly increasing, sometimes almost to the breaking point. The more brilliant but often eccentric scientist, riding on top of the load, may be employed chiefly in pyrotechnic displays which, dazzling as they may be, do little to carry forward the burden. It is the wheel-horse scientist who needs relief and more opportunity for constructive thought.

It is often forgotten that the scientist should disseminate as well as increase human knowledge, and if his work to this end is measured by results the American man of science has much neglected his duty. I venture the opinion that there is today relatively less popular knowledge of science and less interest in its methods and achievements than there was a generation ago. The Constitution provided that Congress could advance science by enacting laws for granting patents. This was one hundred and thirty-four years ago, when the only concept of scientific investigation was afforded by the work of the inventor. Yet to a large part of our people research and invention are still synonymous terms, and even among those who are well educated there are many who conceive of research as a kind of hocus-pocus that results in brilliant discovery. A scientific genius, they believe, retires to his laboratory with pad and pencil, to emerge twenty-four hours later hungry but triumphant. Much periodical literature that is ostensibly devoted to disseminating science among the people is given over to descriptions of inventions, chiefly of the simplest type, with no discussion of the principles involved.

The lack of popular knowledge of science is, I hold, directly due to the form in which science is presented. It has been found easier to multiply specialized technical vocabularies than to express results in clear and precise English. We have followed too blindly the German scientists, who with all their thoroughness seldom elucidate principles either clearly or forcibly. They have invented that wonderful word "allgemeinwissenschaftlichverstandlichkeit," though few of them have had occasion to use it. The German has the advantage of a language that may be written in an accepted form and yet be com-

paratively incomprehensible, and this without even recourse to a specially invented jargon. Some American investigators seem to agree with one school of German thought, holding that science is for the chosen few and that the mass of the people must take scientific orders rather than explanations. Indeed, we are not altogether free from scientific snobbery, by which the results of research are held to be sacred to the elect.

Perhaps the greatest need of the average American scientist of the present day is to learn to write clear English. How can we hope that the people will respect and support science if we give them its message in words that they cannot understand? The seriousness of the situation is brought home by the fact that scientists themselves often cannot understand the expositions of their colleagues. If American investigators are to abandon the use of our common tongue, we must needs invent a scientific Esperanto. What we may call the stenography of science, expressed by the vocabulary of the specialist, the formula of the chemist, and the equations of the mathematician, is necessary, yet the masters of scientific exposition have been able to present their conclusions without too great use of these mysterious symbols. It is not to be denied that the progress of science has made it necessary to coin words for new facts and new theories. The invention of new words has not ended there, however, for they often express only old facts and old ideas. Scientific writings are also made needlessly obscure by refinements in the use of technical words that are in no way essential to the main thesis. Moreover, long and unusual words are often preferred to shorter words that are in more common use. Some scientists appear to believe that unless their writings are ponderous they will lose standing among their colleagues. As a consequence, when a scientific treatise is written in such form as to be understood by the average educated man, the public exclaims at the marvel.

Someone has described sociology as a science which tells us what we already know in words we cannot understand. Even though this may be a slander, much scientific writing is open to the same criticism. Scientific treatises so camouflaged with technical phraseology as to obscure their paucity of ideas are not unknown. It is sometimes forgotten that clear writing is the offspring of clear thinking. Those who doubt that science can be presented in both elegant and clear diction should turn to the treatises by the French, and that this is not a matter of language is shown by some scholarly expositions by the British.

It is a striking fact that relatively few popular scientific works are now being written in this country. In a recent list prepared by a committee of this Academy a large percentage of the books were written by Englishmen. In scientific textbooks America probably leads—certainly in numbers. Most of these books, however, are written for the pedant, and no matter how valuable they may be for his use they are not likely to awaken popular interest in the subject treated. Indeed, some of them appear to have been prepared for the market rather than because the author had any message to convey.

The Federal scientist, because of his direct responsibility to the people, deserves the most censure for the faults of presentation. Many bureaus have, indeed, prepared very good popular treatises on some applications of science, but most of their other publications are couched in technical language that is incomprehensible to all but the specialists. Some of their results, with the aid of the newspapers, have been reduced to popular form, but most of these "translations," as we may call them, are written for the unthinking man, who is generally willing to take his science on faith and therefore meeds no expositions. To meet his supposed needs science is "melodramatized," and startling discoveries are emphasized at the expense of presenting principles. The form of the "stories" in the sensational press is followed more often than that of the expositions of art, history, and literature found in our best periodicals. What is needed is the presentation of science in a form comprehensible to the educated and thinking man, and this work must needs be done by the investigator himself. The other important work of interpreting science for the mass of the people can best be left to those who have special talent for the task. It should be said for the Federal investigator that for most of his work he is not always given the time necessary for clear writing. He therefore has recourse to scientific jargon and sometimes, indeed, leaves to the devoted bureau editor the correction of his faults of diction.

Research may be popularized not only by properly presenting its results, but by informing the public of its purpose and methods; and in this too there is room for much improvement. The investigator who runs true to type avoids rather than courts publicity; he asks nothing more than to be left to solve his own problems. This desire has become almost a mania in many scientists, both to their own detriment and to that of the public. Publicity has therefore been left to the occasional worker who is far from willing to hide his light under a bushel. The public, almost entirely ignored by the average

scientist, finds this exceptional type, usually not a difficult task, and takes him at his own valuation. In so doing it may forget that the efficiency of a steam engine cannot be gaged by the volume of sound produced by its whistle. If science is permitted to reach the average man principally through the agency of a few self-selected mouthpieces, investigators have only themselves to blame. There is no higher mission than the dissemination of science among the people, and those who undertake it with no thought of self-glorification and often at the expense of their own researches certainly deserve the highest praise.

A more amusing and perhaps less valuable type is the restless scientist. He usually devotes far more time to exposition than to origination. If the activities of the restless scientist take the form of publication, they may appear with the noise and regularity of the projectiles from a machine gun. We should remember, however, that the destructive effect of an automatic weapon is due to volume of fire rather than to accuracy of aim; also that its projectiles are machine made and of light weight. At other times the restless scientist manifests himself by close attention to public meetings. No convention, society, or committee is complete without him, and if not on the platform he is at least on a front seat. His voice is heard in favor of the most popular reform of the day, and he is critical of his colleagues who do not join the chorus.

We marvel at the publicity scientist, who often seems to be bearing the weight of the Nation on his shoulders, but we must acknowledge that he may be a valuable member of the body politic. Though he has usually abandoned research, yet he stirs up his less progressive colleagues, and, above all, he keeps science in the public eye. Some of these men are doing most valuable work, and it is not for those who hold themselves aloof from the public to take them to task. He who sacrifices his own scientific career with the purpose of bringing to the people better knowledge of the results, needs, and methods of science merits the highest praise and should have the full support of every scientist. Adverse criticism must be reserved for him whose publicity work is largely devoted to self-advertising.

The working corps of publicity scientists is recruited in part from the Federal service, but I believe the Federal recruits are outnumbered by those from other sources. Recent legislative restrictions have rather discouraged the activities of the familiar type of traveling scientist of the Federal service, who was most often found elsewhere than in his own laboratory.

There is an old Washington story worth recording, though probably it is familiar to you all. A visitor, much impressed with the large number of specialists included in the membership of a local club, expressed his enthusiasm by exclaiming, "You can ask no question in the Cosmos Club but you will find the man who will give the answer." One of his auditors, long resident in the city, remarked "Yes, and I know the man." He had reference to one of a type that may be designated as the "professional prominent scientist." This type, though not unknown elsewhere, was at one time conspicuous in Washington and was the popular authority on all scientific questions. A new problem was the signal for at least a half-column interview, in which a final dictum was pronounced. Though he sometimes failed to impress his colleagues with the profundity of his knowledge, the public was ever ready to worship at his shrine. His evolution, a perfectly natural one, was due to the craving of the man on the street for an understanding of something of science, a craving satisfied by but few investigators. He served a valuable purpose, and the popularizing of science has certainly lost ground since the position of scientist laureate has become vacant.

The first gun at Liége, inaugurating the upheaval that was destined to shake the foundations of civilization, opened a new field for science, which the coming of peace greatly expanded. The call for help from a distressed world was responded to by every scientist, whose one thought was to discover how he might be of service, and every branch of science took an account of stock to learn what it might offer. In the first years of war the titles of presidential addresses to scientific societies were almost stereotyped; they were all expositions showing how this or that science could be made useful.

Federal science both gained and lost by the tumult of war—gained because its results found a seller's market and finally received recognition; lost because after the war the investigator learned that his services were valued much higher by industry than by the Government. In that brilliant coterie of leaders in thought and action gathered at Washington by the war, the Federal scientist shone, if only by reflected light. If in that, as in all other wars, the volunteer received more glory than the regular, the regular at least gained more than ever before.

It detracts in no way from the splendid war service rendered by every scientific institution in the country to assert that the Federal bureaus were the backbone of war science. They were the vast store-

houses of scientific facts that could at once be drawn upon, and the energies of their great corps of investigators were quickly turned toward the problems of war. As hardly a field of science was not utilized, so hardly one was unrepresented at Washington among its thousand investigators. At the outbreak of the war this great army was fully mobilized, and its staffs were organized. Though not so well disciplined as some wished, it was necessarily better prepared to go over the top at the zero hour than the new recruits, seasoned veterans though many of them were.

At no other time in our history were there gathered together so large a number of leaders of business affairs, and many of these were for the first time awakened to the high commercial value of science. With the signing of the armistice the dollar-a-year man returned to his more lucrative occupation, while the Federal scientist was left to divide his attention between high scientific ideals and high cost of living. The dollar-a-year man lost no time in garnering into his affairs some of the Federal scientists whom he had learned to value during the war. He went further than that, for he robbed the universities of some of their most earnest advocates of pure science.

It seems remarkable that the end of a period when devotion to public duty was the very keynote of the Nation should be marked by a widespread desertion of the Federal service. Men who had long sacrificed their own and their families' comfort found the task no longer to their liking. Veteran Government scientists who had for years continued in the service because of devotion to their ideals realized that their war colleagues from private life were willing, the emergency past, to abandon public service for more lucrative employment. Many investigators no doubt held that they too had done their share of public work and were not called upon for further sacrifice. The loss to the Federal service of experienced investigators is well known though this audience will hardly be willing to accept the statement that "all the able scientists have left the Government service." The egress from the service after the war was so large that the crowded condition of the trains leaving Washington must have been due in part to ex-Government scientists who were being transported to more lucrative positions. Quite as alarming as this loss, though less well advertized, is the difficulty of filling vacancies by the best men from the universities, for it has come to pass that the Federal service now often has only second choice. Many of the best-trained men, who formerly chose the career of Government investigator, now pass directly from the university into commercial life.

This turnover of scientific personnel in the Federal service is to be deplored, for the newcomers are at best but ill trained compared with those that have gone, and they are strangers to the traditions of the service. No doubt some of our critics will regard this as a not unmixed evil, because they hold that bureau chiefs exercise the same functions as the beadles of the University of Göttingen, whose principal duty, according to Heine, was to prevent any enterprising Privat-docent from smuggling new ideas into the institution.

The present trend of the best university graduates away from research and toward industry is a most serious threat to the future of science. Its causes are many and include financial and other post-war conditions. May it not, however, also be in part due to a certain lowering of the ideals of the university student? Because of the high cost of living the teaching staffs of universities, like those of other research institution, have been depleted. Strenuous efforts have been made to increase the salary of the professor, but some of the universities have been forced to temporize by allowing him to devote a part of his time to commercial work. In others the professor, though not actually employed in the business world, has been forced to eke out his small income by preparing textbooks instead of by advancing research. Are we then not justified in asking whether a student's ideal to advance knowledge will be greatly developed by a "revered master" whose academic work is frequently interrupted by industrial demands, or whose contributions to science are textbooks, some of them only too evidently prepared with a view to profit?

Another by-product of the war which may do evil to science is the widespread and more or less blind worship of so-called efficiency. The post-war restlessness has developed a popular fervor for everything that is new or different from what has gone before. No one can find fault with the plan of bringing all scientific activities to the highest degree of efficiency, but there are differences of opinion as to how this can best be accomplished. The American people are sometimes carried away by sentiment rather than by cold reasoning, and any new cause, after receiving the proper label, is pressed forward without thoughtful analysis. Sweeping generalizations are made by unthinking men, and if they make a popular appeal they may receive the assent of the majority. The economies forced by the post-war conditions have made efficiency a national fetish. Unfortunately, the word efficiency has to many lost its true meaning, and because of the success of a certain definite system of improved administration

or operation in industrial plants, it is assumed that a like system should be adopted for all other activities. It is therefore quite possible that the methods of efficiency employed in industry may soon be applied to research. Though no one has yet claimed that these methods would improve our output in literature, this use of them would not be very different from their use in scientific investigation.

Another present popular fetish whose worship is closely related to that of efficiency is the fallacy that all advance has been made by the work of the executive. Our rapid material success has been due largely to the executive, yet the most effective worker in advancing civilization has been the thinker. During the war the organizer and leader was the prime necessity, but our success in the war was largely the result of peace-time thinking. War conditions are not favorable to close thought and careful analysis, and though under the stress of national necessity we made many new applications of our knowledge, it may be questioned whether the stress led to any new thought.

The successful administrator has long been our national hero, and the greatest material rewards have come to him; the thinkers and investigators have always taken the second place. This popular worship of the executive has already affected American science, and even the scientist has been drawn into the maelstrom of administrative duties. Good executive heads of scientific institutions are necessary and should by all means come from those who have themselves carried on research. There is now, however, such a furore for organization that many important researches have been interrupted, because the scientist was dragged into all manner of affairs foreign to his training and experience. If this movement continues, a large part of the best investigators will soon be devoting their time to activities of societies, institutions, or committees the avowed purpose of many which is to advance science. It is then a fair question. If most of the energy of American scientists is to be devoted to the advocacy of research, who is to do the actual investigating? We may be coming to a situation in which drastic action must be taken to send the investigator back to his laboratory. Therefore, any plan of advancing pure or applied science, whose execution involves delay in important researches, may better be abandoned.

There is a widespread belief that all faults of the Federal executive departments can be cured by reorganization. Some discordant groupings of Federal bureaus and of their subdivisions, which lead to inefficiency, are evident. These are so conspicuous that they are some-

times taken as proof that the whole plan is faulty. This is not the time nor place to discuss the broad problem of Federal reorganization, but as any basal changes in the scientific service will affect the individual investigator it must be touched upon.

There is now a great hue and cry about duplication of work in the bureaus and departments. Nevertheless, I venture the opinion that there is but little real duplication in the scientific service. There is a twilight zone between all fields of research that may at will be thrown into this or that one, and therefore it has happened that two bureaus approaching a subject from different direction have found themselves in the same field. The old time bitter interbureau controversies over jurisdiction are disappearing, however, as the result of a spirit of cooperation and the application of common sense, rather than by order of higher authority. Though the branches of some scientific bureaus have found among their number certain strange bedfellows, most of these misplacements have been the results of only temporary expedients.

The errors of some plans of reorganization are due to a misunderstanding of the purpose and methods of science and its terminology. Not many years ago a law was proposed providing that all chemical laboratories should be consolidated in a single bureau. The advocates of this measure, having no comprehension of what was included in the science of chemistry, honestly believed that it was a reform which would result in economy and efficiency. As a matter of fact it was as intelligent as if all work requiring the use of the slide rule should be centralized in the Naval Observatory.

It is to be hoped, therefore, that any plan of reorganization will not be based on confusion between the sounds of words and their true meaning. To me it appears that one question to be asked is whether the organization now charged with any given investigation is doing its work well. If the answer is affirmative, it denotes that the organization has an efficient personnel and a strong *esprit de corps*. The integrity of such an organization should not be sacrificed for the sake of a too rigid system of classification.

I venture the opinion that a sound reorganization will provide for a complete divorce between scientific research, on one hand, and the administration of law and the carrying on of miscellaneous Government business, on the other. In the past these latter duties have sometimes come to bureaus established for scientific investigations, and as a result research has suffered. The investigator is by tempera-

ment not fitted for the duty of administering the law or carrying on other business, and those who are qualified for these tasks are usually equally lacking in the ability to direct research. Therefore, the natural division between Federal functions should be recognized by placing the investigator and the administrator in distinct organizations. Where the facts and their interpretation are needed for the proper enforcement of law the investigator should be called upon, but he enters a foreign field when he undertakes to execute laws.

Kipling has said that "There are nine and sixty ways of constructing tribal lays, and every single one of them is right." The intricate dovetailing of scientific research and its manifold applications to industry gives a choice between a large number of perfectly logical classifications. Therefore, reorganization can well seek to maintain the traditions of the scientific service that have been developed during the century of its growth. Mere antiquity cannot, of course be considered an argument in favor of this or that classification; yet in these days of unrest the preservation of an *esprit de corps* that is the outgrowth of long and effective service should not be lightly cast aside, in spite of the fact that it may contravene the principles of the efficiency expert devoted to cultivating mass effort as against individual effort.

In this all too long address I have attempted to set forth the more significant conditions under which Government scientific work goes forward. By way of summary, I may attempt to answer the question, What has a newly appointed scientist to reckon with on entering the Federal service? It would be easiest to follow the example of many others and dwell long on the darker side of the picture, but we must also see the brighter side.

The financial aspect of his situation deserves first attention, for the new-born scientist probably has not yet learned to put behind him all material things. His first important discovery after, say, six years of expensive education will be that his services are valued at less than those of a journeyman plumber with a professional training of six months, during which his earnings have at least covered his keep. If the scientist remains in the service he can look forward with some hope that his income will eventually overtake his expenses, but this only if he lives humbly, as befits one of his lowly station. While dedicating his life to the public weal he may be cheered by the assurance that at the age of seventy, when he will be unfit for private employment except as doorkeeper, he may be retired on an allowance of $60

a month. This and the interest on the debts he has been forced to contract while he has been in the service should suffice to provide the plain living and high thinking to which he has so long been schooled. If he is truly democratic, he will find comfort in the fact that some aged colleague, whose professional duty in the Federal service was to shovel coal, enjoys the same monthly allowance as his own.

The newcomer will find in the Federal service an atmosphere of activity and high pressure that is not always conducive to constructive thought. If he is favored by fortune he may find that his workshop is a modern laboratory, but he is quite as likely to find that the law has relegated him to the dark corner of a crowded room. In such a corner the distraction caused by the inevitable noise and confusion around him may not infrequently prevent the mental concentration essential to good scientific work.

The new assistant will soon discover that his official actions are more or less controlled by very definite regulations, which may prove irksome to one who has recently emerged from the academic freedom of a graduate school. As he gains more experience, however, he will probably come to realize that good administration of a large organization necessitates some rules and restrictions. Or, like some of his colleagues, he may always hold all restrictions imposed by law to be merely symptoms of bureaucracy.

If the young investigator has had a vision of following a path of self-selected research he will meet with bitter disappointment. He must win his spurs before he can ride to combat. He will find his task definitely assigned to him, probably some small, closely supervised investigation. But if he proves his ability, a larger field will surely open out to him. His excellent training will shorten his apprenticeship as compared with that of his predecessor of generations past. This apprenticeship, short though it may be, will form the necessary introduction to independent investigation. In after life he will probably come to see that his best professional training was gained while he was working under the close control of an experienced colleague.

If the scientist has come to Washington with the purpose of dedicating his life to problems that are unsullied by the sordid needs of man, he has committed a blunder. He will soon learn that grants of public funds are seldom made for research that is not directed toward some ultimate goal of material results. To reach the fixed goal, however, investigations in the fundamental principles of science

must be undertaken. The investigator will soon discover that the Federal service is not favorable for him who holds that if he himself is pleasantly occupied, a demand for results is unreasonable. The bureau chief is not sympathetic with the scientist who believes that, if his own life is not long enough to enable him to arrive at a conclusion, posterity can glean sufficient wisdom from his unfinished epoch-making treatise to justify the expenditure of public funds made on his research.

Sooner or later fiscal responsibilities will come to the new scientist, and if he seeks counsel from his older colleagues, some will tell him that the case is hopeless—that the duty of auditors is to interfere with the progress of science by throwing every available obstacle in its path. If, however, he is of an inquiring mind (as even a Federal scientist may be), he may make the startling discovery, new to many of his seniors, that the Federal fiscal system is comparatively simple, so far as it affects the individual investigator; and also that most of its difficulties arise from laws and not from arbitrary regulations. It will, however, be brought home to him that although scientific bureaus may encourage originality, the Treasury officials find no merit in it when it is displayed in expense vouchers.

The young scientist may meet with some surprises at Washington. He may have pictured the Federal scientific service as a close corporation that attempts to impose its conclusions on the scientific world. In fact, however, he will find that members of the service hold the most diverse opinions, that they are themselves the keenest critics of both results and policies, and that by this characteristic the scientist finds himself in an open forum, where new ideas and new interpretations are most heartily welcomed.

He is not unlikely to find his preconception of his bureau chief to be false. Possibly he has pictured him as a cross between a political lobbyist and an advance theatrical agent—one whose decisions are based on expediency rather than on the rights and wrongs of a situation one whose interest in science is prompted solely by the hope of obtaining popular applause. At close range he will probably find his chief a man deeply interested in the progress of science, who, after devoting years of his life to research, has given it up out of a sense of public duty, for the thankless task of administration. Most certainly he will find him a very much overworked man, bearing a heavy responsibility for the expenditure of vast sums of public money and yet constantly harried by just calls for investigations that are far beyond his resources.

It will soon be disclosed to the young scientist that he has joined a corps of well-trained professional men, keenly alive to the scientific and industrial progress of the Nation. Though he will probably never hear the phrases "public duty" and "self-sacrifice," he will find that what these terms mean is earnestly expressed by actions. Nowhere in the world may he find so many scientists, and whatever his specialty he will meet some whose interests are identical with his own—among them probably a recognized international authority in his particular field of inquiry. Again, he will find his own particular field represented in one of the many local societies. Above all, the young scientist will in time come to realize that the mere mass of such an army of investigators, whose scientific ideals are no less because they include the welfare of mankind, gives an inspiration not excelled elsewhere.

SCIENTIFIC NOTES AND NEWS

By a proclamation of President Harding, signed January 24, a 593-acre tract in the Nevada National Forest has been set aside as the Lehman Caves National Monument. The area remains a part of the National Forest, but can be used for no purposes which interfere with its preservation as a national monument. The caves are in a limestone formation at the base of Mt. Wheeler, at an altitude of 7200 feet, and contain a remarkable series of stalactites and stalagmites.

The Pick and Hammer Club met at the Geological Survey on Saturday, February 4. Professor H. A. BROUWER and the members of the Club discussed informally the tectonic theory presented by Dr. BROUWER before the ACADEMY and the Geological Society on February 2.

At the meeting of the Petrologists' Club on January 17, E. T. ALLEN discussed *Chemical sources of volcanic energy*, and L. H. ADAMS, *Physical sources of volcanic energy*. C. S. ROSS presented a brief note on *A peculiar type of igneous rock in Montana*.

At the meeting of the Physics Club of the Bureau of Standards on January 27, Professor LEONARD T. TROLAND, of Harvard University, spoke on *The interrelation of physics and psychology*. This is to be the first of a series of lectures on the borderline between physics, psychology, and physiology.

At the 25th annual meeting of the local Audubon Society on January 25, Dr. A. A. ALLEN, of Cornell University, discussed *Birds and their relation to man*.

Professor H. A. BROUWER, of the Geological Institute, University of Delft, Holland, visited Washington in February. Dr. BROUWER will give a series of lectures at the University of Michigan, in exchange with Professor WILLIAM H. HOBBS, who is now lecturing at Delft.

Mr. EDWIN F. WENDT, formerly a member of the Engineering Board, Department of Valuation, Interstate Commerce Commission, has opened an office in Washington for the general practice of engineering in connection with the valuation and regulation of railroads, telegraphs, and other common carrier properties.